



CLAIMS LISTING

1. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic communications network, comprising:

organizing a wireless electromagnetic communications network, comprising

a set of nodes, said set of nodes further comprising,

at least a first subset wherein each node is MIMO-capable,

comprising:

~~an~~ a spatially diverse antennae array of M antennae, where $M \geq$ one,

a transceiver for each antenna in said spatially diverse antennae array,

means for digital signal processing to convert analog radio signals into digital signals and digital signals into analog radio signals,

means for coding and decoding data, symbols, and control information into and from digital signals,

diversity capability means for transmission and reception of said analog radio signals,

and,

means for input and output from and to a non-radio interface for digital signals;

linking said set of nodes according to design rules that create and support a condition of network reciprocity by meeting ~~at least three out of six of the~~ the first of the following criteria, and at least two out of five of the remaining following criteria:

subdividing said set of nodes into two or more proper subsets of nodes, with a first proper subset being a transmit uplink / receive downlink subset, and a second proper subset being a transmit downlink / receive uplink subset;

allowing each node in said set of nodes to simultaneously belong to up to as many transmitting uplink or receiving uplink subsets as it has diversity capability means;

allowing each node in the transmit uplink / receive downlink subset to simultaneously link to up to as many nodes with which it will hold time and frequency coincident communications in its field of view, as it has diversity capability means;

allowing each node in the transmit downlink / receive uplink subset to simultaneously link to up to as many nodes with which it will hold time and frequency coincident communications in its field of view, as it has diversity capability means;

allowing each member of the transmit uplink / receive downlink subset to engage in simultaneous, time and frequency coincident communications with any other member of that transmit uplink / receive downlink subset only if both that other member also belongs to a different proper subset and the communication is between different proper subsets;

and,

allowing each member of the transmit downlink / receive uplink subset to engage in simultaneous, time and frequency coincident communications with any other member of that transmit downlink / receive uplink subset if both that other member also belongs to a different proper subset and the communication is between different proper subsets;

transmitting, in said wireless electromagnetic communications network, independent information from each node belonging to a first proper subset, to one or more receiving nodes belonging to a second proper subset that are viewable from the transmitting node;

processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset,

information transmitted from one or more nodes belonging to said first proper subset;
and,
dynamically adapting the diversity capability means and said proper subsets to optimize said network.

2. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic communications network, comprising:

organizing a wireless electromagnetic communications network, comprising

a set of nodes, said set of nodes further comprising,

at least a first subset wherein each node is MIMO-capable,
comprising:

a spatially diverse antennae array of M antennae, where $M \geq$ two,

a transceiver for each antenna in said spatially diverse antennae array,

means for digital signal processing to convert analog radio signals into digital signals and digital signals into analog radio signals,

means for coding and decoding data, symbols, and control information into and from digital signals,

diversity capability means for transmission and reception of said analog radio signals,

and,

means for input and output from and to a non-radio interface for digital signals;

linking said set of nodes according to design rules that create and support a condition of network reciprocity by meeting ~~at least three out of six of the~~ the first of the following criteria, and at least two out of five of the remaining following criteria:

subdividing said set of nodes into two or more proper subsets of nodes, with a first proper subset being a transmit uplink / receive downlink subset, and a second proper subset being a transmit downlink / receive uplink subset;
allowing each node in said set of nodes to simultaneously belong to up to as many transmitting uplink or receiving uplink subsets as it has diversity capability means;
allowing each node in a the transmit uplink / receive downlink subset to simultaneously link to up to as many nodes with which it will hold time and frequency coincident communications in its field of view, as it has diversity capability means;
allowing each node in a the transmit downlink / receive uplink subset to simultaneously link to up to as many nodes with which it will hold time and frequency coincident communications in its field of view, as it has diversity capability means;
allowing each member of a the transmit uplink / receive downlink subset to engage in simultaneous time and frequency coincident communications with any other member of that transmit uplink / receive downlink subset only if both that other member also belongs to a different proper subset and the communication is between different proper subsets;
and,
allowing each member of a the transmit downlink / receive uplink subset to engage in simultaneous time and frequency coincident communications with any other member of that transmit downlink / receive uplink subset only if both that other member also belongs to a different proper subset and the communication is between different proper subsets;
transmitting, in said wireless electromagnetic communications network, independent information from each node belonging to a first proper subset, to one

or more receiving nodes belonging to a second proper subset that are viewable from the transmitting node;
processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;
and,
dynamically adapting the diversity capability means and said proper subsets to optimize said network.

3. (CURRENTLY AMENDED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

using substantive null steering to minimize ~~SINR~~ Signal-to-Interference-and-Noise-Ratio (SINR) between nodes transmitting and receiving information.

4. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

using max-SINR null- and beam-steering to minimize intra-network interference.

5. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

using MMSE null- and beam-steering to minimize intra-network interference.

152 6. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
153 adapting the diversity capability means and said proper subsets to optimize said network
154 further comprises:

155 designing the network such that reciprocal symmetry exists for each pairing of
156 uplink receive and downlink receive proper subsets.

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159 7. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
160 adapting the diversity capability means and said proper subsets to optimize said network
161 further comprises:

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163 designing the network such that substantial reciprocal symmetry exists for each
164 pairing of uplink receive and downlink receive proper subsets.

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167 8. (original) A method as in claim 1, wherein the network uses TDD communication
168 protocols.

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171 9. (original) A method as in claim 1, wherein the network uses FDD communication
172 protocols.

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175 10. (original) A method as in claim 3, wherein the network uses simplex communication
176 protocols.

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179 11. (original) A method as in claim 1, wherein the network uses random access packets,
180 and receive and transmit operations are all carried out on the same frequency channels for
181 each link.

12. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises

if the received interference is spatially white in both link directions, setting

$$\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q) \text{ and } \mathbf{g}_1(q) \propto \mathbf{w}_1^*(q) \text{ at both ends of the link,}$$

where

$\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights used in the downlink;

but if the received interference is not spatially white in both link directions, constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to preferentially satisfy:

$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2$$

13. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein:

a proper subset may incorporate one or more nodes that are in a receive-only mode for every diversity capability means.

14. (original) A method as in claim 1, wherein:

the network may dynamically reassign a node from one proper subset to another.

15. (original) A method as in claim 1, wherein:

the network may dynamically reassign a proper subset of nodes from one proper subset to another.

16. (PREVIOUSLY PRESENTED) A method as in claim 7, wherein the step of designing the network such that substantial reciprocal symmetry exists for the uplink and downlink channels further comprises:

if the received interference is spatially white in both link directions, setting

$\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link, where

$\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights used in the downlink;

but if the received interference is not spatially white in both link directions,

constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to preferentially satisfy:

$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2 .$$

17. (CANCELLED)

18. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises

using at each node the receive combiner weights as transmit distribution weights during subsequent transmission operations, so that the network is preferentially designed and constrained such that each link is substantially reciprocal, such that the ad hoc network capacity measure can be made equal in both link directions by setting at both ends of the link:

$$\mathbf{g}_2(k,q) \propto \mathbf{w}_2^*(k,q) \text{ and } \mathbf{g}_1(k,q) \propto \mathbf{w}_1^*(k,q) ,$$

where $\{\mathbf{g}_2(k,q), \mathbf{w}_1(k,q)\}$ are the linear transmit and receive weights to transmit data $d_2(k,q)$ from node $n_2(q)$ to node $n_1(q)$ over channel k in the downlink, and where $\{\mathbf{g}_1(k,q), \mathbf{w}_2(k,q)\}$ are the linear transmit and receive weights used to transmit data $d_1(k,q)$ from node $n_1(q)$ back to node $n_2(q)$ over equivalent channel k in the uplink.

19. (CURRENTLY AMENDED) A method as in claim 1, wherein the step of linking said set of nodes according to design rules further comprises:

designing the topological, physical layout of nodes to support the ~~favor~~ed-criteria within the node's diversity capability means' limitations.

20. (CURRENTLY AMENDED) A method as in claim 1, wherein the step of linking said set of nodes according to design rules further comprises:

designing the topological, physical layout of nodes to support the ~~favor~~ed-criteria within the node's diversity capability means' limitations.

260 21. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
261 dynamically adapting the diversity capability means and said proper subsets to optimize
262 said network further comprises:

263 allowing a proper subset to send redundant data transmissions over multiple
264 frequency channels to another proper subset.

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267 22. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
268 dynamically adapting the diversity capability means and said proper subsets to optimize
269 said network further comprises:

270 allowing a proper subset to send redundant data transmissions over multiple
271 simultaneous or differential time slots to another proper subset.

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274 23. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of linking
275 and substep of subdividing said set of nodes into two or more proper subsets of nodes,
276 does so using as the diversity capability means for transmission and reception of said
277 analog radio signals spatial diversity of antennae.

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280 24. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of linking
281 and substep of subdividing said set of nodes into two or more proper subsets of nodes,
282 does so using as the diversity capability means for transmission and reception of said
283 analog radio signals polarization diversity of antennae.

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286 25. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of linking
287 and substep of subdividing said set of nodes into two or more proper subsets of nodes,
288 does so using as the diversity capability means for transmission and reception of said
289 analog radio signals any combination of temporal, spatial, and polarization diversity of
290 antennae.

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292 26. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
293 dynamically adapting the diversity capability means and said proper subsets to optimize
294 said network further comprises:

295 incorporating network control and feedback aspects as part of the signal encoding
296 process.

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299 27. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
300 dynamically adapting the diversity capability means and said proper subsets to optimize
301 said network further comprises:

302 incorporating network control and feedback aspects as part of the signal encoding
303 process and including said as network information in one direction of the
304 signalling and optimization process, using the perceived environmental
305 condition's effect upon the signals in the other direction of the signalling and
306 optimization process.

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309 28. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
310 dynamically adapting the diversity capability means and said proper subsets to optimize
311 said network further comprises:

312 adjusting the diversity capability means use between any proper sets of nodes by
313 rerouting any active link based on perceived unacceptable SINR experienced on
314 that active link and the existence of an alternative available link using said
315 adjusted diversity capability means.

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318 29. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
319 dynamically adapting the diversity capability means and said proper subsets to optimize
320 said network further comprises:

321 switching a particular node from one proper subset to another due to changes in
322 the external environment affecting links between that node and other nodes in the
323 network.

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326 30. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
327 dynamically adapting the diversity capability means and said proper subsets to optimize
328 said network further comprises:

329 dynamically reshuffling proper subsets to more closely attain network objectives
330 by taking advantage of diversity capability means availability.

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333 31. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
334 dynamically adapting the diversity capability means and said proper subsets to optimize
335 said network further comprises:

336 dynamically reshuffling proper subsets to more closely attain network objectives
337 by accounting for node changes.

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340 32. (CURRENTLY AMENDED) A method as in claim 31, wherein said node
341 changes include any of:

342 adding diversity capability means to a node, adding a new node within the field of
343 view of another node, removing a node from the network (temporarily or
344 permanently), or losing diversity capability at a node.

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347 33. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
348 dynamically adapting the diversity capability means and said proper subsets to optimize
349 said network further comprises:

350 suppressing unintended recipients or transmitters by the imposition of signal
351 masking.

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354 34. (original) A method as in claim 33, wherein the step of suppressing unintended

355 recipients or transmitters by the imposition of signal masking further comprises:

356 imposition of an origination mask.

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359 34. (CANCELLED)

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362 35. (original) A method as in claim 33, wherein the step of suppressing unintended

363 recipients or transmitters by the imposition of signal masking further comprises:

364 imposition of any combination of origination and recipient masks.

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367 36. (PREVIOUSLY PRESENTED) A method as in claim 33, wherein the step of

368 dynamically adapting the diversity capability means and said proper subsets to optimize

369 said network further comprises:

370 using signal masking to secure transmissions against unintentional, interim

371 interception and decryption by the imposition of a signal mask at origination, the

372 transmission through any number of intermediate nodes lacking said signal mask,

373 and the reception at the desired recipient which possesses the correct means for

374 removal of the signal mask.

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377 37. (original) A method as in claim 36, wherein the signal masking is shared by a proper

378 subset.

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381 38. (CURRENTLY AMENDED) A method as in claim 1, wherein the step of
382 dynamically adapting the diversity capability means and said proper subsets to optimize
383 said network further comprises:
384 ~~heterogenous~~ heterogeneous combination of a hierarchy of proper subsets, one
385 within the other, each paired with a separable subset wherein the first is a transmit
386 uplink and the second is a transmit downlink subset, such that the first subset of
387 each pair of subsets is capable of communication with the members of the second
388 subset of each pair, yet neither subset may communicate between its own
389 members.
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392 39. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
393 dynamically adapting the diversity capability means and said proper subsets to optimize
394 said network further comprises:
395 using as many of the available diversity capability means as are needed for traffic
396 between any two nodes from 1 to NumChannels, where NumChannels equals the
397 maximal diversity capability means between said two nodes.
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400 40. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
401 dynamically adapting the diversity capability means and said proper subsets to optimize
402 said network further comprises:
403 using a water-filling algorithm to route traffic between an origination and
404 destination node through any intermediate subset of nodes that has available
405 diversity capability means capacity.
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408 41. (CURRENTLY AMENDED) A method for optimizing a wireless
409 electromagnetic communications network, comprising:
410 organizing a wireless electromagnetic communications network, comprising
411 a set of nodes, said set further comprising,

at least a first subset of MIMO-capable nodes, each MIMO-capable node comprising:

- a spatially diverse antennae array of M antennae, where $M \geq$ two, said antennae array being polarization diverse, and circularly symmetric, and providing 1-to- M RF feeds;
- a transceiver for each antenna in said array, said transceiver further comprising
 - a Butler Mode Forming element, providing spatial signature separation with a FFT-LS algorithm, reciprocally forming a transmission with shared receiver feeds, such that the number of modes out equals the numbers of antennae, establishing such as an ordered set with decreasing energy, further comprising:
 - a dual-polarization element for splitting the modes into positive and negative polarities with opposite and orthogonal polarizations, that can work with circular polarizations, and
 - a dual-polarized link CODEC;
- a transmission/reception switch comprising,
 - a vector OFDM receiver element;
 - a vector OFDM transmitter element;
 - a LNA bank for a receive signal, said LNA Bank also instantiating low noise characteristics for a transmit signal;
 - a PA bank for the transmit signal that receives the low noise characteristics for said transmit signal from said LNA bank;
 - an AGC for said LNA bank and PA bank;

442 a controller element for said
443 transmission/reception switch enabling
444 baseband link distribution of the energy over
445 the multiple RF feeds on each channel to
446 steer up to K_{feed} beams and nulls
447 independently on each FDMA channel;
448 a Frequency Translator;
449 a timing synchronization element controlling
450 said controller element;
451 further comprising a system clock,
452 a universal Time signal element;
453 GPS;
454 a multimode power management element
455 and algorithm;
456 and,
457 a LOs element;
458 said vector OFDMreceiver element comprising
459 an ADC bank for downconversion of
460 received RF signals into digital signals;
461 a MT DEMOD element for multitone
462 demodulation, separating the received signal
463 into distinct tones and splitting them into 1
464 through K_{feed} FDMA channels, said
465 separated tones in aggregate forming the
466 entire baseband for the transmission, said
467 MT DEMOD element further comprising
468 a Comb element with a multiple of 2
469 filter capable of operating on a 128-
470 bit sample; and,
471 an FFT element with a 1,024 real-IF
472 function;

473 a Mapping element for mapping the
474 demodulated multitone signals into a 426
475 active receive bins, wherein
476 each bin covers a bandwidth of 5.75
477 MHz;
478 each bin has an inner passband of
479 4.26 MHz for a content envelope;
480 each bin has an external buffer, up
481 and down, of 745 kHz;
482 each bin has 13 channels, CH0
483 through CH12, each channel having
484 320 kHz and 32 tones, T0 through
485 T31, each tone being 10 kHz, with
486 the inner 30 tones being used
487 information bearing and T0 and T31
488 being reserved;
489 each signal being 100 μ s, with 12.5
490 μ s at each end thereof at the front
491 and rear end thereof forming
492 respectively a cyclic prefix and
493 cyclic suffix buffer to punctuate
494 successive signals;
495 a MUX element for timing modification
496 capable of element-wise multiplication
497 across the signal, which halves the number
498 of bins and tones but repeats the signal for
499 high-quality needs;
500 a link CODEC, which separates each FDMA
501 channel into 1 through M links, further
502 comprising
503 a SOVA bit recovery element;

504 an error coding element;
 505 an error detection element;
 506 an ITI remove element;
 507 a tone equalization element;
 508 and,
 509 a package fragment retransmission
 510 element;
 511 a multilink diversity combining element,
 512 using a multilink Rx weight adaptation
 513 algorithm for Rx signal weights $\mathbf{W}(k)$
 514 to adapt transmission gains $\mathbf{G}(k)$ for each
 515 channel k ;
 516 an equalization algorithm, taking the signal
 517 from said multilink diversity combining
 518 element and controlling a delay removal
 519 element;
 520 said delay removal element separating signal
 521 content from imposed pseudodelay and
 522 experienced environmental signal delay, and
 523 passing the content-bearing signal to a
 524 symbol-decoding element;
 525 said symbol-decoding element for
 526 interpretation of the symbols embedded in
 527 the signal, further comprising:
 528 an element for delay gating;
 529 a QAM element; and
 530 a PSK element;
 531 said vector OFDM transmitter element comprising:
 532 a DAC bank for conversion of digital signals
 533 into RF signals for transmission;

534 a MT MOD element for multitone
 535 modulation, combining and joining the
 536 signal to be transmitted from 1 through K_{feed}
 537 FDMA channels, said separated tones in
 538 aggregate forming the entire baseband for
 539 the transmission, said MT MOD element
 540 further comprising
 541 a Comb element with a multiple of 2
 542 filter capable of operating on a 128-
 543 bit sample; and,
 544 an IFFT element with a 1,024 real-IF
 545 function;
 546 a Mapping element for mapping the
 547 modulated multitone signals from 426
 548 active transmit bins, wherein
 549 each bin covers a bandwidth of 5.75
 550 MHz;
 551 each bin has an inner passband of
 552 4.26 MHz for a content envelope;
 553 each bin has an external buffer, up
 554 and down, of 745 kHz;
 555 each bin has 13 channels, CH0
 556 through CH12, each channel having
 557 320 kHz and 32 tones, T0 through
 558 T31, each tone being 10 kHz, with
 559 the inner 30 tones being used
 560 information bearing and T0 and T31
 561 being reserved;
 562 each signal being-100 μs , with 12.5
 563 μs at each end thereof at the front
 564 and rear end thereof forming

565 respectively a cyclic prefix and
566 cyclic suffix buffer to punctuate
567 successive signals;
568 a MUX element for timing modification
569 capable of element-wise multiplication
570 across the signal, which halves the number
571 of bins and tones but repeats the signal for
572 high-quality needs;
573 a symbol-coding element for embedding the
574 symbols to be interpreted by the receiver in
575 the signal, further comprising:
576 an element for delay gating;
577 a QAM element; and
578 a PSK element;
579 a link CODEC, which aggregates each
580 FDMA channel from 1 through M links,
581 further comprising
582 a SOVA bit recovery element;
583 an error coding element;
584 an error detection element;
585 an ITI remove element;
586 a tone equalization element;
587 and,
588 a package fragment retransmission
589 element;
590 a multilink diversity distribution element,
591 using a multilink Tx weight adaptation
592 algorithm for Tx signal weights to adapt
593 transmission gains $\mathbf{G}(k)$ for each channel
594 k , such that $\mathbf{g}(q;k) \propto \mathbf{w}^*(q;k)$;

a TCM codec;
a pilot symbol CODEC element that integrates with said
FFT-LS algorithm a link separation, a pilot and data signal
elements sorting, a link detection, multilink combination,
and equalizer weight calculation operations;
means for diversity transmission and reception,
and,
means for input and output from and to a non-radio
interface;

linking said set of nodes according to design rules that create and support a
condition of network reciprocity by meeting ~~at least three out of six of the~~ the first
of the following criteria, and at least two out of five of the remaining following
criteria:

subdividing said set of nodes into two or more proper subsets of
nodes, with a first proper subset being a transmit uplink / receive
downlink subset, and a second proper subset being a transmit
downlink / receive uplink subset;

allowing each node in said set of nodes to simultaneously belong
to only as many transmitting uplink or receiving uplink subsets as
it has diversity capability means;

allowing each node in a the transmit uplink / receive downlink
subset to simultaneously link to only as many nodes with which it
will hold time and frequency coincident communications in its
field of view, as it has diversity capability means;

allowing each node in a the transmit downlink / receive uplink
subset to simultaneously link to only as many nodes with which it

will hold time and frequency coincident communications in its field of view, as it has diversity capability means;

allowing each member of a the transmit uplink / receive downlink subset to engage in simultaneous, time and frequency coincident communications with any other member of that transmit uplink / receive downlink subset only if both that other member also belongs to a different proper subset and the communication is between different proper subsets;

and,

allowing each member of a the transmit downlink / receive uplink subset to engage in simultaneous, time and frequency coincident communications with any other member of that transmit downlink / receive uplink subset only if both that other member also belongs to a different proper subset and the communication is between different proper subsets;

transmitting, in said wireless electromagnetic communications network, independent information from each node belonging to a first proper subset, to one or more receiving nodes belonging to a second proper subset that are viewable from the transmitting node;

processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;

and,

designing the network such that substantially reciprocal symmetry exists for the uplink and downlink channels by,

if the received interference is spatially white in both link directions, setting

$\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link,

where $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights used in the downlink;

but if the received interference is not spatially white in both link

directions, constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to satisfy:

$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$$

using any standard communications protocol, including TDD, FDD, simplex,

and,

optimizing the network by dynamically adapting the ~~diversity capability~~ diversity capability means between nodes of said transmitting and receiving subsets.

42. (CANCELLED)

43. (CANCELLED)

681 44. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
682 dynamically adapting the diversity capability means and said proper subsets to optimize
683 said network further comprises:

684 optimizing at each node acting as a receiver the receive weights using a MMSE
685 technique to adjust the multitone transmissions between it and other nodes.

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688 45. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
689 dynamically adapting the diversity capability means and said proper subsets to optimize
690 said network further comprises:

691 optimizing at each node acting as a receiver the receive weights using the MAX
692 maximum SINR to adjust the multitone transmissions between it and other nodes.

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695 46. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
696 dynamically adapting the diversity capability means and said proper subsets to optimize
697 said network further comprises:

698 optimizing at each node acting as a receiver the receive weights, then optimizing
699 the transmit weights at that node by making them proportional to the receive
700 weights, and then optimizing the transmit gains for that node by a max-min
701 criterion for the link capacities for that node at that particular time.

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704 47. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
705 dynamically adapting the diversity capability means and said proper subsets to optimize
706 said network further comprises:

707 including, as part of said network, one or more network controller elements that
708 assist in tuning local node's maximum capacity criteria and link channel diversity
709 usage to network constraints.

712 48. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
713 dynamically adapting the diversity capability means and said proper subsets to optimize
714 said network further comprises:

715 characterizing the channel response vector $\mathbf{a}_1(f, t; n_2, n_1)$ by the observed
716 (possibly time-varying) azimuth and elevation $\{\theta_1(t; n_2, n_1),$
717 $\varphi_1(f, t; n_2, n_1)\}$ of node n_2 observed at n_1 .

718
719
720 49. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
721 dynamically adapting the diversity capability means and said proper subsets to optimize
722 said network further comprises:

723 characterizing the channel response vector $\mathbf{a}_1(f, t; n_2, n_1)$ as a superposition of
724 direct-path and near-field reflection path channel responses, e.g., due to scatterers
725 in the vicinity of n_1 , such that each element of $\mathbf{a}_1(f, t; n_2, n_1)$ can be modeled
726 as a random process, possibly varying over time and frequency.

727
728
729 50. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
730 dynamically adapting the diversity capability means and said proper subsets to optimize
731 said network further comprises:

732 presuming that $\mathbf{a}_1(f, t; n_2, n_1)$ and $\mathbf{a}_1(f, t; n_1, n_2)$ can be substantively
733 time invariant over significant time durations, e.g., large numbers of OFDM
734 symbols or TDMA time frames, and inducing the most significant frequency and
735 time variation by the observed timing and carrier offset on each link.

51. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

in such networks, e.g., TDD networks, wherein the transmit and receive frequencies are identical ($f_{21}(k) = f_{12}(k) = f(k)$) and the transmit and receive time slots are separated by short time intervals ($t_{21}(l) = t_{12}(l) + \Delta_{21} \approx t(l)$), and $\mathbf{H}_{21}(k, l)$ and $\mathbf{H}_{12}(k, l)$ become substantively reciprocal, such that the subarrays comprising $\mathbf{H}_{21}(k, l)$ and $\mathbf{H}_{12}(k, l)$ satisfy $\mathbf{H}_{21}(k, l; n_2, n_1) \approx \delta_{21}(k, l; n_1, n_2) \mathbf{H}_{12}^T(k, l; n_1, n_2)$, where $\delta_{21}(k, l; n_1, n_2)$ is a unit-magnitude, generally nonreciprocal scalar, equalizing the observed timing offsets, carrier offsets, and phase offsets, such that $\lambda_{21}(n_2, n_1) \approx \lambda_{12}(n_1, n_2)$, $\tau_{21}(n_2, n_1) \approx \tau_{12}(n_1, n_2)$, and $\nu_{21}(n_1, n_2) \approx \nu_{12}(n_1, n_2)$, by synchronizing each node to an external, universal time and frequency standard, obtaining $\delta_{21}(k, l; n_2, n_1) \approx 1$, and establishing network channel response as truly reciprocal $\mathbf{H}_{21}(k, l) \approx \mathbf{H}_{12}^T(k, l)$.

52.(original) A method as in claim 51, wherein the synchronization of each node is to Global Position System Universal Time Coordinates (GPS UTC).

53. (original) A method as in claim 51, wherein the synchronization of each node is to a network timing signal.

54. (original) A method as in claim 51, wherein the synchronization of each node is to a combination of Global Position System Universal Time Coordinates (GPS UTC) and a network timing signal.

55. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

for such parts of the network where the internode channel responses possess substantive multipath, such that $\mathbf{H}_{21}(k, l; n_2, n_1)$ and $\mathbf{H}_{12}(k, l; n_1, n_2)$ have rank greater than unity, making the channel response substantively reciprocal by:

(1) forming uplink and downlink transmit signals using the matrix formula

$$\mathbf{s}_1(k, l; n_1) = \mathbf{G}_1(k, l; n_1) \mathbf{d}_1(k, l; n_1)$$

$$\mathbf{s}_2(k, l; n_1) = \mathbf{G}_2(k, l; n_2) \mathbf{d}_2(k, l; n_2);$$

(2) reconstructing the data intended for each receive node using the matrix formula

$$\mathbf{y}_1(k, l; n_1) = \mathbf{W}_1^H(k, l; n_1) \mathbf{x}_1(k, l; n_1)$$

$$\mathbf{y}_2(k, l; n_2) = \mathbf{W}_2^H(k, l; n_2) \mathbf{x}_2(k, l; n_2);$$

(3) developing combiner weights that $\{\mathbf{w}_1(k, l; n_2, n_1)\}$ and $\{\mathbf{w}_2(k, l; n_1, n_2)\}$ that substantively null data intended for recipients during the symbol recovery operation, such that for $n_1 \neq n_2$:

(4) developing distribution weights $\{\mathbf{g}_1(k, l; n_2, n_1)\}$ and $\{\mathbf{g}_2(k, l; n_1, n_2)\}$ that perform equivalent substantive nulling operations during transmit signal formation operations;

(5) scaling distribution weights to optimize network capacity and/or power criteria, as appropriate for the specific node topology and application addressed by the network;

(6) removing residual timing and carrier offset remaining after recovery of the intended network data symbols;

and

(7) encoding data onto symbol vectors based on the end-to-end SINR obtainable between each transmit and intended recipient node, and decoding that data after symbol recovery operations, using channel coding and decoding methods develop in prior art.

56. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

forming substantively nulling combiner weights using an FFT-based least-squares algorithms that adapt $\{\mathbf{w}_1(k, l; n_2, n_1)\}$ and $\{\mathbf{w}_2(k, l; n_1, n_2)\}$ to values that minimize the mean-square error (MSE) between the combiner output data and a known segment of transmitted pilot data;

applying the pilot data to an entire OFDM symbol at the start of an adaptation frame comprising a single OFDM symbol containing pilot data followed by a stream of OFDM symbols containing information data;

wherein the pilot data transmitted over the pilot symbol is preferably given by

$$\begin{aligned}
 p_1(k; n_2, n_1) &= d_1(k, 1; n_2, n_1) \\
 &= p_{01}(k) p_{21}(k; n_2) p_{11}(k; n_1) \\
 p_2(k; n_1, n_2) &= d_2(k, 1; n_1, n_2) \\
 &= p_{02}(k) p_{12}(k; n_1) p_{22}(k; n_2)
 \end{aligned}$$

814 such that the “pseudodelays” $\delta_1(n_1)$ and $\delta_2(n_2)$ are unique to each transmit
 815 node (in small networks), or provisioned at the beginning of communication with
 816 any given recipient node (in which case each will be a function of n_1 and n_2),
 817 giving each pilot symbol a pseudorandom component;

818 maintaining minimum spacing between any pseudodelays used to communicate
 819 with a given recipient node that is larger than the maximum expected timing
 820 offset observed at that recipient node, said spacing should also being an integer
 821 multiple of $1/K$, where K is the number of tones used in a single FFT-based LS
 822 algorithm;

823 and if K is not large enough to provide a sufficiency of pseudodelays, using
 824 additional OFDM symbols for transmission of pilot symbols, either lengthening
 825 the effective value of K , or reducing the maximum number of originating nodes
 826 transmitting pilot symbols over the same OFDM symbol;

827 also providing K large enough to allow effective combiner weights to be
 828 constructed from the pilot symbols alone;

829 then obtaining the remaining information-bearing symbols, which are the uplink
 830 and downlink data symbols provided by prior encoding, encryption, symbol
 831 randomization, and channel preemphasis stages, in the adaptation frame, by using

$$832 \quad d_1(k, l; n_2, n_1) = p_1(k; n_2, n_1) d_{01}(k, l; n_2, n_1)$$

$$833 \quad d_2(k, l; n_1, n_2) = p_2(k; n_1, n_2) d_{02}(k, l; n_1, n_2);$$

834 removing at the recipient node, first the pseudorandom pilot components from the
 835 received data by multiplying each tone and symbol by the pseudorandom
 836 components of the pilot signals, using

$$837 \quad d_2(k, l; n_1, n_2) = p_2(k; n_1, n_2) d_{02}(k, l; n_1, n_2)$$

$$\mathbf{x}_{02}(k, l; n_2) = c_{01}(k; n_2) \mathbf{x}_2(k, l; n_2);$$

thereby transforming each authorized and intended pilot symbol for the recipient node into a complex sinusoid with a slope proportional to the sum of the pseudodelay used during the pilot generation procedure, and the actual observed timing offset for that link, and leaving other, unauthorized pilot symbols, and symbols intended for other nodes in the network, untransformed and so appearing as random noise at the recipient node.

57. (PREVIOUSLY PRESENTED) A method as in claim 55, wherein the FFT-Least Squares algorithm further comprises:

using a pilot symbol, which is multiplied by a unit-norm FFT window function; passing that result to a QR decomposition algorithm and computing orthogonalized data $\{\mathbf{q}(k)\}$ and an upper-triangular Cholesky statistics matrix \mathbf{R} ;

then multiplying each vector element of $\{\mathbf{q}(k)\}$ by the same unit-norm FFT window function and passing it through a zero-padded inverse Fast Fourier Transform (IFFT) with output length PK , with padding factor P to form uninterpolated, spatially whitened processor weights $\{\mathbf{u}(m)\}$, where lag index m is proportional to target pseudodelay $\delta(m) = m/PK$;

then using the spatially whitened processor weights to estimate the mean-square-error (MSE) obtaining for a signal received at each target pseudodelay,

$\varepsilon(m) = 1 - \|\mathbf{u}(m)\|^2$, yielding a detection statistic (pseudodelay indicator

function), with an extreme at IFFT lags commensurate with the observed pseudodelay and designed to minimize interlag interference between pilot signal features in the pseudodelay indicator function;

using an extremes-finding algorithm to detect each extreme;

estimating the location of the observed pseudodelays to sub-lag accuracy;

determining additional ancillary statistics;

selecting the extremes beyond a designated MSE threshold;
 interpolating spatially whitened weights \mathbf{U} from weights near the extremes;
 using the whitened combiner weights \mathbf{U} to calculate both unwhitened combiner
 weights $\mathbf{W} = \mathbf{R}^{-1}\mathbf{U}$ to be used in subsequent data recovery operations, and to
 estimate the received channel aperture matrix $\mathbf{A} = \mathbf{R}^H\mathbf{U}$, to facilitate ancillary
 signal quality measurements and fast network entry in future adaptation frames;
 and, lastly,
 using an estimated and optimized pseudodelay vector δ_* to generate $\mathbf{c}_1(k) =$
 $\exp\{-j2\pi\delta_*k\}$ (conjugate of $\{p_{11}(k; n_1)\}$ during uplink receive
 operations, and $\{p_{22}(k; n_2)\}$ during downlink receive operations), which is then
 used to remove the residual observed pseudodelay from the information bearing
 symbols.

58. (original) A method as in claim 55, wherein the pseudodelay estimation is refined
 using a Gauss-Newton recursion using the approximation :

$$\exp\{-j2\pi\Delta(k-k_0)/PK\} \approx 1 -j2\pi\Delta(k-k_0)/PK.$$

59. (CURRENTLY AMENDED) A method as in claim 1, wherein ~~wherein~~
 dynamically adapting the diversity[capability means and said proper subsets to optimize
 said network further comprises:

using the linear combiner weights provided during receive operations are
 construct linear distribution weights during subsequent transmit operations, by
 setting distribution weight $\mathbf{g}_1(k, l; n_2, n_1)$ proportional to
 $\mathbf{w}_1^*(k, l; n_2, n_1)$ during uplink transmit operations, and

892 $\mathbf{g}_2(k, l; n_1, n_2)$ proportional to $\mathbf{w}_2^*(k, l; n_1, n_2)$ during downlink
893 transmit operations; thereby making the transmit weights substantively nulling
894 and thereby allowing each node to form frequency and time coincident two-way
895 links to every node in its field of view, with which it is authorized (through
896 establishment of link set and transfer of network/recipient node information) to
897 communicate.

898
899

900 60. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the substep of
901 dynamically adapting the diversity capability means and said proper subsets to optimize
902 said network at each node in the first subset of nodes further comprises:
903 using a LEGO implementation element and algorithm.

904
905

906 61. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
907 adapting the diversity capability means and said proper subsets to optimize said network
908 further comprises:
909 balancing the power use against capacity for each channel, link, and node, and
910 hence for the network as a whole by:

911 establishing a capacity objective $\{\beta(m)\}$ for a user 2 node receiving
912 from a user 1 node as the target to be achieved by the user 2 node;
913 solving, at the user 2 node the local optimization problem:

914
$$\min \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1, \text{ such that}$$

915
$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m),$$

916 where $\pi_1(q)$ is the transmit power for link number q for the user
917 1 node,

918 $\gamma(q)$ is the signal to interference and noise ratio (SINR) seen at
 919 the output of the beamformer,
 920 $\mathbf{1}$ is a vector of all 1s,
 921 and,
 922 $\boldsymbol{\pi}_1$ is a vector whose q^{th} element is $\pi_1(q)$,
 923 the aggregate set $Q(m)$ contains a set of links that are grouped
 924 together for the purpose of measuring capacity flows through those
 925 links;
 926 using at the user 2 node the local optimization solution to moderate the
 927 transmit and receive weights, and signal information, returned to [user 1
 928 node;
 929 and,
 930 using said feedback to compare against the capacity objective $\{\beta(m)\}$
 931 and incrementally adjust the transmit power at each of the user 1 node and
 932 the user 2 node until no further improvement is perceptible.
 933
 934

935 62. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
 936 adapting the diversity capability means and said proper subsets to optimize said network
 937 further comprises:

938 using the downlink objective function

$$\begin{aligned}
 939 \quad & \min \sum_q \pi_2(q) = \mathbf{1}^T \boldsymbol{\pi}_2 \text{ such that } \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \\
 940 \quad & \beta(m)
 \end{aligned}$$

941 at each node to perform local optimization;
 942 reporting the required feasibility condition,

$$943 \quad \sum_{q \in Q(m)} \pi_1(q) \leq R_1(m);$$

944 and,
945 modifying $\beta(m)$ as necessary to stay within the constraint.
946
947
948 63. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:
949 the capacity constraints $\beta(m)$ are determined in advance for each proper subset
950 of nodes, based on known QoS requirements for each said proper subset.
951
952
953 64. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network
954 further seeks to minimize total power in the network as suggested by
955
$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m).$$

956
957
958 65. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network sets
959 as a target objective for the network $\{\beta(m)\}$ the QoS for the network.
960
961
962 66. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network sets
963 as a target objective for the network $\{\beta(m)\}$ a vector of constraints.
964
965
966 67. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the local
967 optimization problem is further defined such that:
968
969 the receive and transmit weights are unit normalized with respect to the
970 background interference autocorrelation matrix;
971

972 the local SINR is expressed as

$$\gamma(q) = \frac{P_{rt}(q, q)\pi_t(q)}{1 + \sum_{j \neq q} P_{rt}(q, j)\pi_t(j)} ;$$

973
974

975 and the weight normalization

$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

976

977 is used to enable $D_{12}(\mathbf{W}, \mathbf{G}) = D_{21}(\mathbf{G}^*, \mathbf{W}^*)$, where $(\mathbf{W}_2, \mathbf{G}_1)$

978 and $(\mathbf{W}_1, \mathbf{G}_2)$ represent the receive and transmit weights employed by all
979 nodes in the network during uplink and downlink operations, respectively, at that
980 node, thereby allowing the uplink and downlink function to be presumed identical
981 rather than separately computed.

982

983

984 68. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:

985 very weak constraints to the transmit powers are approximated by using a very

986 simple approximation for $\gamma(q)$.

987

988

989 69. (PREVIOUSLY PRESENTED) A method as in claim 61, for the cases wherein all
990 the aggregate sets contain a single link and non-negligible environmental noise is present,
991 wherein the transmit powers are computed as Perron vectors from

$$\begin{aligned}
D_{21} &= \log \left(1 + \frac{1}{\rho(\mathbf{P}_{21}) - 1} \right) \\
&= \log \left(1 + \frac{1}{\rho(\mathbf{P}_{12}^T) - 1} \right); \\
&= D_{12}
\end{aligned}$$

and a simple power constraint is imposed upon the transmit powers.

70. (PREVIOUSLY PRESENTED) A method as in claim 69, wherein the optimization is performed in alternating directions and repeated.

71. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node presumes the post-beamforming interference energy remains constant for the adjustment interval and so solves

$$\min_{\pi_1(q)} \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1, \text{ subject to the constraint of}$$

$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

using classic water filling arguments based on Lagrange multipliers, and then uses a similar equation for the reciprocal element of the link.

72. (CURRENTLY AMENDED) ~~A method~~ A method as in claim 61, wherein at each node the constrained optimization problem stated in

$$\max_m \sum_{q \in Q(m)} \log(1 + \gamma(q)), \text{ such that}$$

1012
$$\sum_{q \in Q(m)} \pi_1(q) \leq R_1(m), \gamma(q) \geq 0$$

1013 is solved using the approximation

1014
$$\gamma(q) = \frac{P_{21}(q, q) \pi_1(q)}{i_2(q)}$$

1015 and the network further comprises at least one high-level network controller that controls
1016 the power constraints $R_1(m)$, and drives the network towards a max-min solution.

1017

1018

1019 73. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node:

1020 is given an initial γ_0 ;

1021 generates the model expressed in

1022
$$L(\gamma, \mathbf{g}, \beta) = \mathbf{g}^T \gamma, \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

1023
$$\mathbf{g} = \nabla_{\gamma} f(\gamma_0);$$

1024 updates the new γ_{α} from

1025
$$\gamma_* = \arg \min_{\gamma} L(\gamma, \mathbf{g}, \beta), \gamma_{\alpha} = \gamma_0 + \alpha(\gamma_* - \gamma_0);$$

1026 determines a target SINR to adapt to; and,

1027 updates the transmit power for each link q according to

1028
$$\pi_2(q) = \gamma_{\alpha} i_1(q) / |h(q)|^2$$

1029
$$\pi_1(q) = \gamma_{\alpha} i_2(q) / |h(q)|^2.$$

1030

1031

1032 74. (PREVIOUSLY PRESENTED) A method as in claim 61, for each node wherein the
1033 transmit power relationship of

$$1034 \quad \pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

$$1035 \quad \pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2$$

1036 is not known, that:

1037 uses a suitably long block of N samples is used to establish the relationship, where

1038 N is either 4 times the number of antennae or 128, whichever is larger;

1039 uses the result to update the receive weights at each end of the link;

1040 optimizes the local model as in

$$1041 \quad \gamma_* = \arg \min_{\gamma} L(\gamma, \mathbf{g}, \beta)$$

$$1042 \quad \gamma_\alpha = \gamma_0 + \alpha(\gamma_* - \gamma_0);$$

1043 and then applies

$$1044 \quad \pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

$$1045 \quad \pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2.$$

1046

1047

1048 75. (PREVIOUSLY PRESENTED) A method as in claim 61 that, for an aggregate

1049 proper subset m :

1050 for each node within the set m , inherits the network objective function model

1051 given in

$$1052 \quad L_m(\gamma, \mathbf{g}, \beta) = \sum_{q \in Q(m)} \mathbf{g}_q \gamma(q)$$

$$1053 \quad \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

$$1054 \quad g(q) = i_1(q)i_2(q) / |h(q)|^2 ;$$

1055 eliminates a step of matrix channel estimation, transmitting instead from
1056 that node as a single real number for each link to the other end of said link
1057 an estimate of the post beamforming interference power;
1058 and ,
1059 receives back for each link a single real number being the transmit power.

1060
1061

1062 76. (PREVIOUSLY PRESENTED) A method as in claim 74, that for each pair of
1063 nodes assigns to the one presently possessing the most processing capability the power
1064 management computations.

1065
1066

1067 77. (PREVIOUSLY PRESENTED) A method as in claim 75 that estimates the transfer
1068 gains and the post beamforming interference power using simple least squares estimation
1069 techniques.

1070
1071

1072 78. (PREVIOUSLY PRESENTED) A method as in claim 75 that, for estimating the
1073 transfer gains and post beamforming interference power:

1074

1075 instead solves for the transfer gain h using

1076
$$y(n) = hgs(n) + \varepsilon(n);$$

1077 uses a block of N samples of data to estimate h using

1078
$$h = \frac{\sum_{n=1}^N s^*(n)y(n)}{\sum_{n=1}^N |s(n)|^2 g}$$

1079 obtains an estimation of residual interference power $[R_\varepsilon]$ using

$$R_{\varepsilon} = \left\langle \left| \varepsilon(n) \right|^2 \right\rangle$$

1080

$$= \frac{1}{N} \sum_{n=1}^N \left(\left| y(n) \right|^2 - \left| ghs(n) \right|^2 \right)$$

1081

and,

1082

obtains knowledge of the transmitted data symbols $S(n)$ from using

1083

remodulated symbols at the output of the codec.

1084

1085 79. (PREVIOUSLY PRESENTED) A method as in claim 78 wherein, instead of
 1086 obtaining knowledge of the transmitted data symbols $S(n)$ from using remodulated
 1087 symbols at the output of the codec, the node uses the output of a property restoral
 1088 algorithm used in a blind beamforming algorithm.

1089

1090

1091 80. (PREVIOUSLY PRESENTED) A method as in claim 78 wherein, instead of
 1092 obtaining knowledge of the transmitted data symbols $S(n)$ from using remodulated
 1093 symbols at the output of the codec, the node uses a training sequence explicitly
 1094 transmitted to train beamforming weights and asset the power management algorithms.

1095

1096

1097 81. (PREVIOUSLY PRESENTED) A method as in claim 78 wherein, instead of
 1098 obtaining knowledge of the transmitted data symbols $S(n)$ from using remodulated
 1099 symbols at the output of the codec, the node uses any combination of:

1100

the output of a property restoral algorithm used in a blind beamforming algorithm;

1101

a training sequence explicitly transmitted to train beamforming weights and asset

1102

the power management algorithms;

1103

and,

1104

other means known to the art.

1105 82. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node
1106 incorporates a link level optimizer and a decision algorithm.
1107
1108
1109 83. (PREVIOUSLY PRESENTED) A method as in claim 82, wherein the decision
1110 algorithm is a Lagrange multiplier technique.
1111
1112
1113 84. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the solution to
1114 $\min_{\pi_1(q)} \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1$ is implemented by a penalty function technique.
1115
1116
1117 85. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty
1118 function technique:
1119 takes the derivative of $\chi(q)$ with respect to $\boldsymbol{\pi}_1$;
1120 and,
1121 uses the Kronecker-Delta function and the weighted background noise.
1122
1123
1124 86. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty
1125 function technique neglects the noise term.
1126
1127
1128 87. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty
1129 function technique normalizes the noise term to one.
1130
1131
1132 88. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the
1133 approximation uses the receive weights.

89. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein adaptation to the target objective is performed in a series of measured and quantized descent and ascent steps.

90. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the adaptation to the target objective is performed in response to information stating the vector of change.

91. (PREVIOUSLY PRESENTED) A method as in claim 61, which uses the log linear mode

$$\beta_q \approx \log \left(\frac{a \pi_1(q) + a_0}{b \pi_1(q) + b_0} \right) = \hat{\beta}_q(\pi_1(q))$$

and the inequality characterization $\hat{\beta}_q(\pi_1(q)) \geq \beta$ to solve the approximation problem with a simple low dimensional linear program.

92. (PREVIOUSLY PRESENTED) A method as in claim 61, develops the local mode by matching function values and gradients between the current model and the actual function.

93. (PREVIOUSLY PRESENTED) A method as in claim 61, which develops the model as a solution to the least squares fit, evaluated over several points.

94. (PREVIOUSLY PRESENTED) A method as in claim 61, which reduces the cross-coupling effect by allowing only a subset of links to update at any one particular time,

1161 wherein the subset members are chosen as those which are more likely to be isolated
1162 from one another.

1163

1164

1165 95. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:

1166 the network further comprises a network controller element;

1167 said network controller element governs a subset of the network;

1168 said network controller element initiates, monitors, and changes the target

1169 objective for that subset;

1170 said network controller communicates the target objective to each node in that

1171 subset;

1172 and,

1173 receives information from each node concerning the adaptation necessary to meet

1174 said target objective.

1175

1176

1177 96. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein said network

1178 further records the scalar and history of the increments and decrements ordered by the

1179 network controller.

1180

1181

1182 97. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a

1183 target objective may be a power constraint.

1184

1185

1186 98. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a

1187 target objective may be a capacity maximization subject to a power constraint.

1188

1189

1190 99. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a
1191 target objective may be a power minimization subject to the capacity attainment to the
1192 limit possible over the entire network.
1193
1194
1195 100. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a
1196 target objective may be a power minimization at each particular node in the network
1197 subject to the capacity constraint at that particular node.
1198
1199
1200 101. (CURRENTLY AMENDED) A wireless electromagnetic communications
1201 network, comprising:
1202 ~~a wireless electromagnetic communications network, comprising~~
1203 a set of nodes, said set further comprising,
1204 at least a first subset wherein each node is MIMO-capable,
1205 comprising:
1206 a spatially diverse antennae array of M antennae, where M
1207 \geq one,
1208 a transceiver for each antenna in said array,
1209 means for digital signal processing,
1210 means for coding and decoding data and symbols,
1211 means for diversity transmission and reception,
1212 and,
1213 means for input and output from and to a non-radio
1214 interface;
1215 said set of nodes further comprising one or more proper subsets of nodes,
1216 being at least one transmitting and at least one receiving subset, with said
1217 transmitting and receiving subsets having a topological arrangement
1218 whereby:

1219 each node in a transmitting subset has no more nodes with which it
 1220 will simultaneously communicate in its field of view, than it has
 1221 number of antennae;
 1222 each node in a receiving subset has no more nodes with which it
 1223 will simultaneously communicate in its field of view, than it can
 1224 steer independent nulls to;
 1225 and,
 1226 each member of a non-proper subset cannot communicate with any
 1227 other member of its non-proper subset;
 1228 means for transmitting independent information from each node in a first non-
 1229 proper subset to one or more receiving nodes belonging to a second non-proper
 1230 subset that are viewable from the transmitting node;
 1231 means for processing independently information transmitted to a receiving node
 1232 in a second non-proper subset from one or more nodes in a first non-proper subset
 1233 is independently by the receiving node;
 1234 and,
 1235 means for optimizing the network by dynamically adapting the means for diversity
 1236 transmission and reception between nodes of said transmitting and receiving subsets.
 1237
 1238
 1239 102. (PREVIOUSLY PRESENTED) An apparatus as in claim 101, further
 1240 comprising means for scheduling according to a Demand-Assigned, Multiple-Access
 1241 algorithm.
 1242
 1243
 1244 103. (PREVIOUSLY PRESENTED) An apparatus as in claim 101, further
 1245 comprising a LEGO adaptation-element for each node in said first subset.
 1246
 1247
 1248 104. (PREVIOUSLY PRESENTED) An apparatus as in claim 101, further comprising:
 1249 a LEGO adaptation-element for each node in said first subset

1250 and,
1251 one or more network controllers.
1252
1253
1254 105. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
1255 dynamically adapting the diversity capability means and said proper subsets to optimize
1256 said network further comprises:
1257 matching each transceiver's degrees of freedom (DOF) to the nodes in the
1258 possible link directions;
1259 equalizing those links to provide node-equivalent uplink and downlink capacity.
1260
1261
1262 106. (original) A method as in claim 105, further comprising, after the DOF matching:
1263 assigning asymmetric transceivers to reflect desired capacity weighting;
1264 adapting the receive weights to form a solution for multipath resolutions;
1265 employing data and interference whitening as appropriate to the local conditions;
1266 and,
1267 using retrodirective transmission gains during subsequent transmission operations.
1268
1269
1270 107. (original) A method as in claim 105, wherein the receive weights are matched to the
1271 nodes in the possible link directions.
1272
1273
1274 108. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic
1275 communications network, comprising:
1276 organizing a wireless electromagnetic communications network; comprising
1277 a set of nodes, said set of nodes further comprising,
1278 at least a first subset wherein each node is MIMO-capable,
1279 comprising:
1280 an antennae array of M antennae, where $M \geq$ one,

1281 a transceiver for each antenna in said spatially diverse
1282 antennae array,
1283 means for digital signal processing to convert analog radio
1284 signals into digital signals and digital signals into analog
1285 radio signals,
1286 means for coding and decoding data, symbols, and control
1287 information into and from digital signals,
1288 diversity capability means for transmission and reception of
1289 said analog radio signals;
1290 and,
1291 means for input and output from and to a non-radio
1292 interface for digital signals;
1293 linking said set of nodes according to design rules that create and support a
1294 condition of network reciprocity by meeting ~~at least three out of six of the~~ the first
1295 of the following criteria, and at least two out of five of the remaining following
1296 criteria:
1297
1298 subdividing said set of nodes into two or more proper subsets of
1299 nodes, with a first proper subset being a transmit uplink / receive
1300 downlink subset, and a second proper subset being a transmit
1301 downlink / receive uplink subset;
1302
1303 allowing each node in said set of nodes to simultaneously belong
1304 to up to as many transmitting uplink or receiving uplink subsets as
1305 it has diversity capability means;
1306
1307 allowing each node in a the transmit uplink / receive downlink
1308 subset to simultaneously link to up to as many nodes with which it
1309 will hold time and frequency coincident communications in its
1310 field of view, as it has diversity capability means;
1311

1312 allowing each node in a the transmit downlink / receive uplink
 1313 subset to simultaneously link to up to as many nodes with which it
 1314 will hold time and frequency coincident communications in its
 1315 field of view, as it has diversity capability means;
 1316
 1317 allowing each member of a the transmit uplink / receive downlink
 1318 subset to engage in simultaneous time and frequency coincident
 1319 communications with any other member of that transmit uplink /
 1320 receive downlink subset only if both that other member also
 1321 belongs to a different proper subset and the communication is
 1322 between different proper subsets;
 1323 and,
 1324 allowing each member of a transmit downlink / receive uplink
 1325 subset to engage in simultaneous time and frequency coincident
 1326 communications with any other member of that transmit downlink
 1327 / receive uplink subset only if both that other member also belongs
 1328 to a different proper subset and the communication is between
 1329 different proper subsets;
 1330 transmitting, in said wireless electromagnetic communications network,
 1331 independent information from each node belonging to a first proper subset, to one
 1332 or more receiving nodes belonging to a second proper subset that are viewable
 1333 from the transmitting node;
 1334
 1335 processing independently, in said wireless electromagnetic communications
 1336 network, at each receiving node belonging to said second proper subset,
 1337 information transmitted from one or more nodes belonging to said first proper
 1338 subset;
 1339
 1340 optimizing at the local level for each node for the channel capacity D_{21}
 1341 according to

$D_{21} = \max \beta$ such that

$$\beta \leq \sum_{q \in U(m)} \sum_k \log(1 + \gamma(k, q)),$$

$$\gamma(k, q) \geq 0,$$

$$\sum_m R_1(m) \leq R,$$

$$\pi_1(k, q) \geq 0,$$

$$\sum_{q \in U(m)} \sum_k \pi_1(k, q) \leq R_1(m)$$

;

solving first the reverse link power control problem; then treating the forward link problem in an identical fashion, substituting the subscripts 2 for 1 in said equation;

and,

dynamically adapting the diversity capability means and said proper subsets to optimize said network.

109. (CURRENTLY AMENDED) A method as in claim 108, ~~further~~ further comprising:

for each aggregate subset m , attempting to achieve the given capacity objective, β , as described in

$$\min_{\pi_r(q)} \sum_{q \in Q(m)} \pi_r(q), \quad \text{such that}$$

$$\beta = \sum_{q \in Q(m)} \log(1 + \gamma(q))$$

by:

(1) optimizing the receive beamformers, using simple MMSE processing, to simultaneously optimize the SINR;

1360 (2) based on the individual measured SINR for each q index, attempt to
1361 incrementally increase or lower its capacity as needed to match the current target;
1362 and,
1363 (3) stepping the power by a quantized small step in the appropriate direction;
1364 then,
1365 when all aggregate sets have achieved the current target capacity, then the
1366 network can either increase the target capacity β , or add additional users to
1367 exploit the now-known excess capacity.

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1369

1370 110. (PREVIOUSLY PRESENTED) A method as in claim 107, wherein the network
1371 optimizes for QoS and not diversity capability means capacity.

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1373

1374 111. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein:
1375 said network controller adds, drops, or changes the target capacity for any node in
1376 the set the network controller controls.

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1379 112. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein:
1380 said network controller may, either in addition to or in replacement for altering β ,
1381 add, drop, or change channels between nodes, frequencies, coding, security, or
1382 protocols, polarizations, or traffic density allocations usable by a particular node
1383 or channel.

1384
1385

1386 113. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications
1387 network, comprising:
1388 a set of nodes, said set further comprising,

1389 at least a first subset wherein each node is MIMO-capable,
 1390 comprising:
 1391 a spatially diverse antennae array of M antennae, where M
 1392 \geq one,
 1393 a transceiver for each antenna in said array,
 1394 means for digital signal processing,
 1395 means for coding and decoding data and symbols,
 1396 means for diversity transmission and reception,
 1397 pilot symbol coding & decoding element
 1398 timing synchronization element
 1399 and,
 1400 means for input and output from and to a non-radio
 1401 interface;
 1402 said set of nodes further comprising two or more proper subsets of nodes,
 1403 there being at least one transmitting and at least one receiving subset, with
 1404 said transmitting and receiving subsets subset having a diversity
 1405 arrangement whereby:
 1406 each node in a transmitting subset has no more nodes with which it
 1407 will simultaneously communicate in its field of view, than it has
 1408 number of antennae;
 1409 each node in a receiving subset has no more nodes with which it
 1410 will simultaneously communicate in its field of view, than it can
 1411 steer independent nulls to;
 1412 and,
 1413 each member of a non-proper subset cannot communicate with any
 1414 other member of its non-proper subset over identical diversity
 1415 channels;
 1416 a LEGO adaptation element and algorithm;
 1417 a network controller element and algorithm;

1418 whereby each node in a first non-proper subset transmits independent information
 1419 to one or more receiving nodes belonging to a second non-proper subset that are
 1420 viewable from the transmitting node;
 1421 each receiving node in said second non-proper subset processes independently
 1422 information transmitted to a from one or more nodes in a first non-proper subset is
 1423 independently by the receiving node;
 1424 each node uses means to minimize SINR between nodes transmitting and
 1425 receiving information;
 1426 the network is designed such that substantially reciprocal symmetry exists for the
 1427 uplink and downlink channels by,

1428 if the received interference is spatially white in both link directions, setting
 1429 $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link,
 1430 where $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights used
 1431 in the downlink;

1432
 1433 but if the received interference is not spatially white in both link
 1434 directions, constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to satisfy:

$$1435 \quad \sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

$$1436 \quad \sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$$

1437
 1438 the network uses any standard communications protocol;
 1439 and,
 1440 the network is optimized by dynamically adapting the means for diversity
 1441 transmission and reception between nodes of said transmitting and receiving
 1442 subsets.

1443 114. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications
1444 network as in claim 113:
1445 wherein each node may further comprise a Butler Mode Forming element, to
1446 enable said node to ratchet the number of active antennae for a particular uplink
1447 or downlink operation up or down.

1448
1449

1450 115. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications
1451 network as in claim 101:
1452 incorporating a dynamics-resistant multitone element.

1453
1454

1455 116. (original) The use of a method as described in claim 1 for fixed wireless
1456 electromagnetic communications.

1457
1458

1459 117. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1460 for fixed wireless electromagnetic communications.

1461
1462

1463 118. (original) The use of a method as described in claim 1 for mobile wireless
1464 electromagnetic communications.

1465
1466

1467 119. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1468 for mobile wireless electromagnetic communications.

1469
1470

1471 120. (original) The use of a method as described in claim 1 for mapping operations using
1472 wireless electromagnetic communications.

1473

1474 121. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1475 for mapping operations using wireless electromagnetic communications.
1476

1477 122. (original) The use of a method as described in claim 1 for a military wireless
1478 electromagnetic communications network.
1479

1480 123. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1481 for a military wireless electromagnetic communications network.
1482

1483 124. (original) The use of a method as described in claim 1 for a military wireless
1484 electromagnetic communications network for battlefield operations.
1485

1486 125. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1487 for a military wireless electromagnetic communications network for battlefield
1488 operations.
1489

1490 126. (original) The use of a method as described in claim 1 for a military wireless
1491 electromagnetic communications network for Back Edge of Battle Area (BEBA)
1492 operations.
1493

1494 127. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1495 for a military wireless electromagnetic communications network for Back Edge of Battle
1496 Area (BEBA) operations.
1497

1498 128. (original) The use of a method as described in claim 1 for a wireless electromagnetic
1499 communications network for intruder detection operations.
1500

1501 129. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1502 for a wireless electromagnetic communications network for intruder detection operations.
1503

1504 130. (original) The use of a method as described in claim 1 for a wireless electromagnetic
1505 communications network for logistical intercommunications.

1506

1507 131. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1508 for a wireless electromagnetic communications network for logistical
1509 intercommunications.

1510

1511 132. (original) The use of a method as described in claim 1 in a wireless electromagnetic
1512 communications network for self-filtering spoofing signals.

1513

1514 133. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1515 for a wireless electromagnetic communications network for self-filtering spoofing
1516 signals.

1517

1518 134. (original) The use of a method as described in claim 1 in a wireless
1519 electromagnetic communications network for airborne relay over the horizon.

1520

1521 135. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1522 for a wireless electromagnetic communications network for airborne relay over the
1523 horizon.

1524

1525 136. (original) The use of a method as described in claim 1 in a wireless electromagnetic
1526 communications network for traffic control.

1527

1528 137. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further
1529 comprising the use thereof for air traffic control.

1530

1531 138. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further
1532 comprising the use thereof for ground traffic control.

1533

1534 139. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further
1535 comprising the use thereof for a mixture of ground and air traffic control.
1536

1537 140. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1538 for a wireless electromagnetic communications network for traffic control.
1539

1540 141. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further
1541 comprising the use thereof for air traffic control
1542

1543 142. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further
1544 comprising the use thereof for ground traffic control.
1545

1546 143. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further
1547 comprising the use thereof for a mixture of ground and air traffic control.
1548

1549 144. (original) The use of a method as in claim 1 in a wireless electromagnetic
1550 communications network for emergency services.
1551

1552 145. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1553 wireless electromagnetic communications network for emergency services.
1554

1555 146. (original) The use of a method as in claim 1 in a wireless electromagnetic
1556 communications network for shared emergency communications without interference.
1557

1558 147. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1559 wireless electromagnetic communications network for shared emergency
1560 communications without interference.
1561

1562 148. (original) The use of a method as in claim 1 in a wireless electromagnetic
1563 communications network for positioning operations without interference.
1564

149. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a wireless electromagnetic communications network for positioning operations without interference.

150. (CURRENTLY AMENDED) The use of a method as in claim 1 in a wireless electromagnetic communications network for high ~~reliability~~ reliability networks requiring graceful degradation despite environmental conditions or ~~changes~~ changes.

151. (CURRENTLY AMENDED) The use of an apparatus as in claim 101 in a wireless electromagnetic communications network for high ~~reliability~~ reliability networks requiring graceful degradation despite environmental conditions or ~~changes~~ changes.

152. (original) The use of a method as in claim 1 in a wireless electromagnetic communications network for a secure network requiring assurance against unauthorized intrusion.

153. (original) The use of a method as in claim 1 in a wireless electromagnetic communications network for a secure network requiring message end-point assurance.

154. (original) The use of a method as in claim 1 in a wireless electromagnetic communications network for a secure network requiring assurance against unauthorized intrusion and message end-point assurance.

155. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a wireless electromagnetic communications network for a secure network requiring assurance against unauthorized intrusion.

156. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a wireless electromagnetic communications network for a secure network requiring message end-point assurance.

1596 157. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 In a
1597 wireless electromagnetic communications network for a secure network requiring
1598 assurance against unauthorized intrusion and message end-point assurance.
1599
1600 158. (original) The use of a method as in claim 1 in a cellular mobile radio service.
1601
1602 159. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1603 cellular mobile radio service.
1604
1605 160. (original) The use of a method as in claim 1 in a personal communication service.
1606
1607 161. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1608 personal communication service.
1609
1610 162. (original) The use of a method as in claim 1 in a private mobile radio service.
1611
1612 163. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a private
1613 mobile radio service.
1614
1615 164. (original) The use of a method as in claim 1 in a wireless LAN.
1616
1617 165. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1618 wireless LAN.
1619
1620 166. (original) The use of a method as in claim 1 in a fixed wireless access service.
1621
1622 167. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a fixed
1623 wireless access service.
1624
1625 168. (original) The use of a method as in claim 1 in a broadband wireless access service.
1626

1627 169. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1628 broadband wireless access service.
1629
1630 170. (original) The use of a method as in claim 1 in a municipal area network.
1631
1632 171. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1633 municipal area network.
1634
1635 172. (original) The use of a method as in claim 1 in a wide area network.
1636
1637 173. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a wide
1638 area network.
1639
1640 174. (original) The use of a method as in claim 1 in wireless backhaul.
1641
1642 175. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless
1643 backhaul.
1644
1645 176. (original) The use of a method as in claim 1 in wireless backhaul.
1646
1647 177. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless
1648 backhaul.
1649
1650 178. (original) The use of a method as in claim 1 in wireless SONET.
1651
1652 179. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless
1653 SONET.
1654
1655 180-181. (CANCELLED)
1656
1657 182. (original) The use of a method as in claim 1 in wireless Telematics.

183. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless
Telematics.

184. (PREVIOUSLY PRESENTED) An apparatus as in claim 101, wherein the means
for digital signal processing in said first subset of MIMO-capable nodes further
comprises:

- an ADC bank for downconversion of received RF signals into digital signals;

- a MT DEMOD element for multitone demodulation, separating the received

- signal into distinct tones and splitting them into 1 through K_{feed} FDMA

- channels, said separated tones in aggregate forming the entire baseband for the
transmission, said MT DEMOD element further comprising

- a Comb element with a multiple of 2 filter capable of operating on a 128-
bit sample; and,

- an FFT element with a 1,024 real-IF function;

- a Mapping element for mapping the demodulated multitone signals into a 426
active receive bins, wherein

- each bin covers a bandwidth of 5.75MHz;

- each bin has an inner passband of 4.26MHz for a content envelope;

- each bin has an external buffer, up and down, of 745kHz;

- each bin has 13 channels, CH0 through CH12, each channel having 320

- kHz and 32 tones, T0 through T31, each tone being 10kHz, with the inner

- 30 tones being used information bearing and T0 and T31 being reserved;

- each signal being 100μs, with 12.5μs at each end thereof at the front and

- rear end thereof forming respectively a cyclic prefix and cyclic suffix

- buffer to punctuate successive signals;

- and,

- a symbol-decoding element for interpretation of the symbols embedded in the
signal.

1689

1690 185. (CURRENTLY AMENDED) A wireless electromagnetic communications

1691 network, ~~comprising~~, comprising:

1692 a set of nodes, said set further comprising:

1693 at least a first subset of MIMO-capable nodes, each MIMO-capable node

1694 comprising:

1695 a spatially diverse antennae array of M antennae, where $M \geq$ two,

1696 said antennae array being polarization diverse, and circularly

1697 symmetric, and providing 1-to- M RF feeds;

1698 a transceiver for each antenna in said array, said transceiver

1699 further comprising:

1700 a Butler Mode Forming element, providing spatial

1701 signature separation with a FFT-LS algorithm,

1702 reciprocally forming a transmission with shared receiver

1703 feeds, such that the number of modes out equals the

1704 numbers of antennae, establishing such as an ordered set

1705 with decreasing energy, further comprising:

1706 a dual-polarization element for splitting the

1707 modes into positive and negative polarities with

1708 opposite and orthogonal polarizations, that can

1709 work with circular polarizations; and,

1710 a dual-polarized link CODEC;

1711 a transmission/reception switch comprising:

1712 a vector OFDM receiver element;

1713 a vector OFDM transmitter element;

1714 a LNA bank for a receive signal, said LNA Bank

1715 also instantiating low noise characteristics for a

1716 transmit signal;

1717 a PA bank for the transmit signal that receives

1718 the low noise characteristics for said transmit

1719 signal from said LNA bank;

1720 an AGC for said LNA bank and PA bank;
 1721 a controller element for said
 1722 transmission/reception switch enabling baseband
 1723 link distribution of the energy over the multiple
 1724 RF feeds on each channel to steer up to K_{feed}
 1725 beams and nulls independently on each FDMA
 1726 channel;
 1727 a Frequency Translator;
 1728 a timing synchronization element controlling said
 1729 controller element;
 1730 further comprising a system clock,
 1731 a universal Time signal element;
 1732 GPS;
 1733 a multimode power management element and
 1734 algorithm;
 1735 and,
 1736 a LOs element;
 1737 said vector OFDM receiver element comprising:
 1738 an ADC bank for downconversion of received
 1739 RF signals into digital signals;
 1740 a MT DEMOD element for multitone
 1741 demodulation, separating the received signal into
 1742 distinct tones and splitting them into 1 through
 1743 K_{feed} FDMA channels, said separated tones in
 1744 aggregate forming the entire baseband for the
 1745 transmission, said MT DEMOD element further
 1746 comprising:
 1747 a Comb element with a multiple of 2
 1748 filter capable of operating on a 128-bit
 1749 sample; and,

1750 an FFT element with a 1,024 real-IF
 1751 function;
 1752 a Mapping element for mapping the demodulated
 1753 multitone signals into a 426 active receive bins,
 1754 wherein
 1755 each bin covers a bandwidth of 5.75
 1756 MHz;
 1757 each bin has an inner passband of 4.26
 1758 MHz for a content envelope;
 1759 each bin has an external buffer, up and
 1760 down, of 745 kHz;
 1761 each bin has 13 channels, CH0 through
 1762 CH12, each channel having 320 kHz and
 1763 32 tones, T0 through T31, each tone
 1764 being 10 kHz, with the inner 30 tones
 1765 being used information bearing and T0
 1766 and T31 being reserved;
 1767 and,
 1768 each signal being 100 μ s, with 12.5 μ s at
 1769 each end thereof at the front and rear end
 1770 thereof forming respectively a cyclic
 1771 prefix and cyclic suffix buffer to
 1772 punctuate successive signals;
 1773 a MUX element for timing modification capable
 1774 of element-wise multiplication across the signal,
 1775 which halves the number of bins and tones but
 1776 repeats the signal for high-quality needs;
 1777 a link CODEC, which separates each FDMA
 1778 channel into 1 through M links, further
 1779 comprising:
 1780 a SOVA bit recovery element;

1781 an error coding element;
 1782 an error detection element;
 1783 an ITI remove element;
 1784 a tone equalization element;
 1785 and,
 1786 a package fragment retransmission
 1787 element;
 1788 a multilink diversity combining element, using a
 1789 multilink Rx weight adaptation algorithm for Rx
 1790 signal weights $\mathbf{W}(k)$ to adapt transmission
 1791 gains $\mathbf{G}(k)$ for each channel k ;
 1792 an equalization algorithm, taking the signal from
 1793 said multilink diversity combining element and
 1794 controlling a delay removal element;
 1795 said delay removal element separating
 1796 signal content from imposed pseudodelay
 1797 and experienced environmental signal
 1798 delay, and passing the content-bearing
 1799 signal to a symbol-decoding element;
 1800 said symbol-decoding element for
 1801 interpretation of the symbols embedded
 1802 in the signal, further comprising:
 1803 an element for delay gating;
 1804 a QAM element; and
 1805 a PSK element;
 1806 said vector OFDM transmitter element comprising:
 1807 a DAC bank for conversion of digital signals into
 1808 RF signals for transmission;
 1809 a MT MOD element for multitone modulation,
 1810 combining and joining the signal to be

1811 transmitted from 1 through K_{feed} FDMA
1812 channels, said separated tones in aggregate
1813 forming the entire baseband for the transmission;
1814 said MT MOD element further comprising
1815 a Comb element with a multiple of 2
1816 filter capable of operating on a 128-bit
1817 sample; and,
1818 an IFFT element with a 1,024 real-IF
1819 function;
1820 a Mapping element for mapping the modulated
1821 multitone signals from 426 active transmit bins,
1822 wherein
1823 each bin covers a bandwidth of 5.75
1824 MHz;
1825 each bin has an inner passband of 4.26
1826 MHz for a content envelope;
1827 each bin has an external buffer, up and
1828 down, of 745 kHz;
1829 each bin has 13 channels, CH0 through
1830 CH12, each channel having 320 kHz and
1831 32 tones, T0 through T31, each tone
1832 being 10 kHz, with the inner 30 tones
1833 being used information bearing and T0
1834 and T31 being reserved;
1835 each signal being-100 μs , with 12.5 μs at
1836 each end thereof at the front and rear end
1837 thereof forming respectively a cyclic
1838 prefix and cyclic suffix buffer to
1839 punctuate successive signals;
1840 a MUX element for timing modification capable
1841 of element-wise multiplication across the signal,

1842 which halves the number of bins and tones but
 1843 repeats the signal for high-quality needs;
 1844 a symbol-coding element for embedding the
 1845 symbols to be interpreted by the receiver in the
 1846 signal, further comprising:
 1847 an element for delay gating;
 1848 a QAM element; and
 1849 a PSK element;
 1850 a link CODEC, which aggregates each FDMA
 1851 channel from 1 through M links, further
 1852 comprising:
 1853 a SOVA bit recovery element;
 1854 an error coding element;
 1855 an error detection element;
 1856 an ITI remove element;
 1857 a tone equalization element;
 1858 and,
 1859 a package fragment retransmission
 1860 element;
 1861 a multilink diversity distribution element, using a
 1862 multilink Tx weight adaptation algorithm for Tx
 1863 signal weights to adapt transmission gains
 1864 $\mathbf{G}(k)$ for each channel k , such that $\mathbf{g}(q;k)$
 1865 $\propto \mathbf{w}^*(q;k)$;
 1866 a TCM codec;
 1867 a pilot symbol CODEC element that integrates with said FFT-LS
 1868 algorithm a link separation, a pilot and data signal elements
 1869 sorting, a link detection, multilink combination, and equalizer
 1870 weight calculation operations;
 1871 means for diversity transmission and reception,

1872 and,
1873 means for input and output from and to a non-radio interface;
1874
1875 said set of nodes being linked according to design rules that create and support a
1876 condition of network reciprocity by meeting the first of ~~favor~~ the following
1877 criteria, and at least two out of five of the remaining following criteria:
1878 subdividing said set of nodes into two or more proper subsets of nodes,
1879 with a first proper subset being a transmit uplink / receive downlink
1880 subset, and a second proper subset being a transmit downlink / receive
1881 uplink subset;
1882
1883 allowing each node in said set of nodes to simultaneously belong to only
1884 as many transmitting uplink or receiving uplink subsets as it has diversity
1885 capability means;
1886
1887 allowing each node in the transmit uplink / receive downlink subset to
1888 simultaneously link to only as many nodes with which it will hold time
1889 and frequency coincident communications in its field of view, as it has
1890 diversity capability means;
1891
1892 allowing each node in the transmit downlink / receive uplink subset to
1893 simultaneously link to only as many nodes with which it will hold time
1894 and frequency coincident communications in its field of view, as it has
1895 diversity capability means;
1896
1897 allowing each member of a the transmit uplink / receive downlink subset
1898 to engage in simultaneous, time and frequency coincident communications
1899 with any other member of that transmit uplink / receive downlink subset
1900 only if both that other member also belongs to a different proper subset
1901 and the communication is between different proper subsets;
1902 and,

1903 allowing each member of the transmit downlink / receive uplink subset to
1904 engage in simultaneous, time and frequency coincident communications
1905 with any other member of that transmit downlink / receive uplink subset
1906 only if both that other member also belongs to a different proper subset
1907 and the communication is between different proper subsets;

1908

1909 means for transmitting, in said wireless electromagnetic communications network,
1910 independent information from each node belonging to a first proper subset, to one
1911 or more receiving nodes belonging to a second proper subset that are viewable
1912 from the transmitting node;

1913

1914 means for processing independently, in said wireless electromagnetic
1915 communications network, at each receiving node belonging to said second proper
1916 subset, information transmitted from one or more nodes belonging to said first
1917 proper subset;

1918

1919 and,

1920

1921 means for deploying said set of nodes such that substantially reciprocal symmetry
1922 exists for the uplink and downlink channels by,

1923 if the received interference is spatially white in both link directions, setting

1924 $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link,

1925 where $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights
1926 used in the downlink;

1927

1928 but if the received interference is not spatially white in both link
1929 directions, constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to satisfy:

1930

$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

1932

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$$

1934

1935 using any standard communications protocol, including TDD, FDD, simplex,

1936

1937 and,

1938

1939 means for optimizing the network by dynamically adapting the diversity

1940 capability means between nodes of said transmitting and receiving subsets.

1941

1942

1943 186. (PREVIOUSLY PRESENTED) A network as in claim 185, wherein said a
1944 transmission/reception switch further comprises an element for tone and slot interleaving.

1945

1946

1947 187. (PREVIOUSLY PRESENTED) A network as in claim 185, wherein said TMC
1948 codec and SOVA bit recovery element are replaced with a Turbo codec.

1949

1950

1951 188. (NEW) A method as in claim 33, wherein the step of suppressing unintended
1952 recipients or transmitters by the imposition of signal masking further comprises:

1953 imposition of a recipient mask.